
5
2
3
9
1
8
6
7
4
V.G.L. van Someren.
1919.

5.
Muscid parasitic on
No. 2.

3.
Sceliphron spirifex, Linn.
Larvæ fed on spiders.

2.
Belonogaster griseus F.
Larvæ fed on pulped insects.

EAST AFRICAN HYMENOPTERA.

(Life-size.)

V. G. L. VAN SOMEREN.

1.
Hemipepsis heros, Guér.

9.
Eumenes maxillosa, Dg.

8.
Scolia ruficornis, F.
Lays eggs on larvæ of Beetle
on which young Scolia feeds.

6.
Bembex capensis, Lep.
Larvæ fed on young
Grasshoppers.

7.
Sphex luteipennis, Mocs.

4.
Synagris negusi, Buyss.
Larvæ fed on caterpillars.

That there have been important earth-movements in the country in recent geological times is clear from the general topographic evidence. The narrowness of the valleys, the abundance of waterfalls and rapids, and the direct leap of tributaries from hanging valleys into the main river are all indications that the country has a young topography and that the rivers have not had time to cut down their beds since the last uplift.

That the modern earth-movements extend to the coast is shown by the raised coral reefs which have been uplifted in recent geological times, and, as shown by Mr. Hobley, by successive steps. Hence the crustal disturbances of British East Africa still affect the coastlands, the foundering of whose former eastward extension to India initiated the eruptions and earth-movements to which the country owes its chief features of geological interest.

DISCURSIVE NOTES ON THE FOSSORIAL HYMENOPTERA

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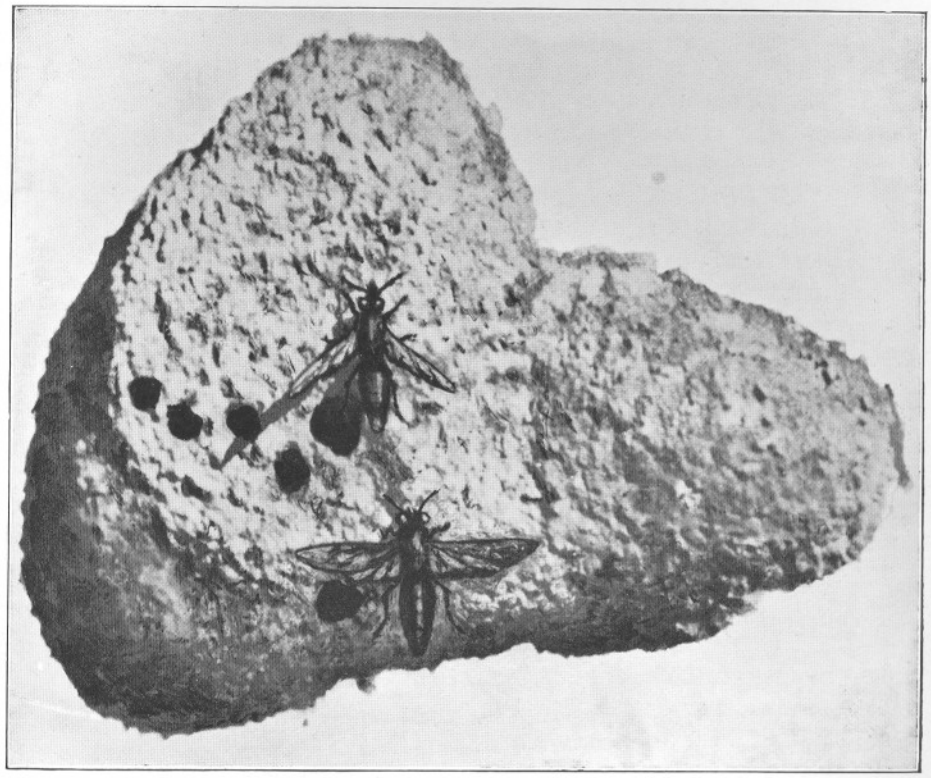
Fossorial, because they dig! *Hymenoptera*, because they belong to the great group of insects characterised by the firm linking together of the anterior and posterior wings on each side.

Popularly, 'sand-wasps'—this is not a bad name, more especially if applied to the *Bembecidæ*, which do look something like an ordinary wasp and do burrow in sand rather than other kinds of earth. Properly speaking, however, the Fossors are not true wasps, in the sense that our black and yellow common or garden wasp is. Anatomically, they are distinguished by the forewing not being folded. In a true wasp, when it alights, the forewing is folded on a longitudinal crease, so that the wings appear only of half their true width:

PHOTO No. 1.



"MUD" NEST OF SYNAGRIS NEGUSI, Buyss.
Top insect settled—wings folded ; bottom about to fly—wings expanded.
Photographed by Dr. G. van Someren.

[*To face p.* 440.

(*vide* Frontispiece, Fig. 4, *Synagris negusi*, and photo No. 1). this is not the case in Fossors. As regards habits, true wasps are often—indeed, are supposed popularly to be always—social, while each Fossor lives entirely an independent life; although, if conditions favour, a number may nest in the same small area, so that in this way they are gregarious. Many true wasps, however, live similar independent lives, and are closely allied in their habits to some of the Fossors.[1] What, then, are the habits which are so important as to give the group its name? The Fossors have brought to a highly specialised standard a habit which is, primarily, quite simple—namely, the feeding of their young with other insects. The common wasp at home may often be noticed to pounce on a fly, cut off its wings and legs, reduce the body to a mangled pulp, and carry it off —to feed upon? No; the adult feeds purely from flowers or on honey stolen from more conscientious workers: the mincemeat is for the brood of young in her parchment nest underground.

A wasp which is very well known out here, *Belonogaster griseus*, F., by name (*vide* Frontispiece, Fig. 2, *Belonogaster griseus*), has added something to this simple method. This is the much-disliked, dark-brown wasp, with very thin pedicle to the abdomen; it constructs parchment nests, hanging from a narrow stalk, in the cells of which, open at the bottom, its larvæ are suspended head downwards. (Photos Nos. 2 and 3.)

Out in the field, one often comes across one of these wasps hunting, and may perhaps witness her discovery of a suitable caterpillar. She *stings* it—often in several places *seriatim*—and then proceeds with her mandibles to reduce the helpless insect to pulp, which she forms into a round ball and carries back to the nest, where other nurses assist in distributing it to the larvæ. Here is a distinct advance; the prey being large might be rather obstreperous under the process of pulping, and is rendered helpless by a preliminary stinging.

This method, however, involves continual supplies of fresh-killed meat and careful attention throughout the whole life of the larva. The next step above the somewhat crude

[1] Compare *Odynerus* with *Sceliphron*.

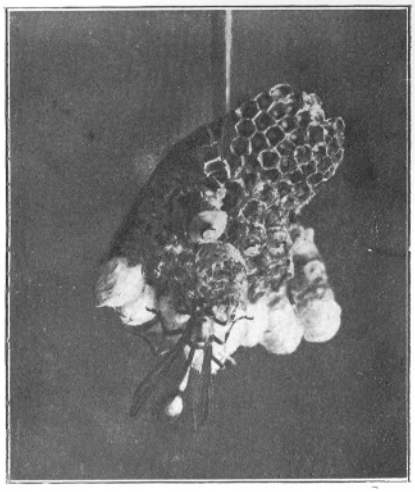
process of the true wasps is perhaps exemplified by Fossors of the family *Bembecidæ*, which, as was said, merit more than most the title 'sand-wasps.' These, so far as my experience goes, only burrow in sandy places; the reason being that they have not yet got beyond the stage of a frequent supply of fresh meat to their young. As the burrow needs to be constantly reopened, the labour would be very great were it not in some light, easily displaced, soil; hence loose sand is chosen. The reason why these Fossors bring daily supplies to their young is perhaps the nature of the prey: two-winged flies are not fleshy insects, and if stored up in number sufficient for the food of the larva until it has finished growing would probably dry up.

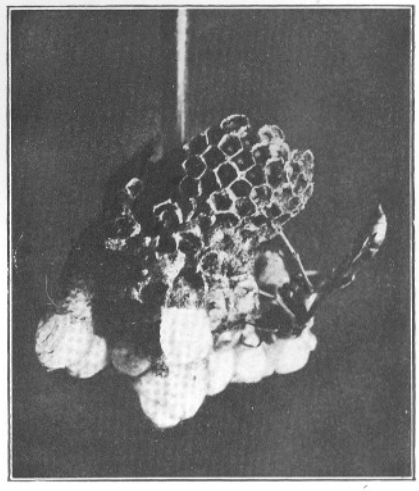
So the Bembecid hunts flies daily, stings each one, and brings it back, whole, to the larva at the bottom of the burrow. I am not quite certain, from memory, whether the Fossor really kills the fly, or only paralyses it, but believe the latter is the case. This method is a distinct advance upon the last mentioned, but still involves frequent reopening of the burrows to introduce fresh supplies. Two other well-known families of Fossors—*Sphegidæ* and *Pompilidæ*—provide once and for all for each larva, by storing up at the bottom of the burrow a supply, according to size, of one or more insects or spiders which have been stung, so that they are paralysed and probably insensitive, but are still alive (*vide* photo No. 4). The helpless Fossor larva thus has live meat in a defenceless condition, and feeds first on the juices and fats only, leaving the vital parts until the end when all save skin is consumed.

A mother Sphegid or Pompilid, having dug her burrow, found her prey, stung it, brought it back to the burrow, laid an egg on it, and filled up the burrow, has fulfilled her duty to *that* egg, and sets to work to provide for another. This method, however, still has its limitations, imposing heavy labour upon the mother; and another family of Fossors, the *Scoliidæ* (*vide* Frontispiece, Fig. 8, *Scolia ruficornis*), seems to have gone one better. Instead of laboriously excavating a burrow the mother Scoliid searches out the destined prey of her young *in its own burrow.*

This is commonly the fat larva of large Lamellicorn beetles,

PHOTO NO. 2.





BELONOGASTER GRISEUS, Fabr.

Constructing cap to cell. Feeding larvæ.

Showing eggs and larvæ in different stages.

Photographed by Dr. G. van Someren.

[*To face p.* 442.

living underground. Scoliids may constantly be seen quartering the ground, and sometimes may be found scratching at the earth, presumably to enable them to reach the subterranean prey which is stung, and has an egg laid upon it. There is no laborious excavating a burrow and dragging a heavy burden thereto: the prey is simply rendered inert and left where it is.

Another family of Fossors, the *Mutillidæ*, has improved upon even this method. Like the man in the parable, they cannot dig, but then they do not need to; for their prey is usually[1] the larvæ of other *Hymenoptera*, whose nests are often freely exposed—such as those made by 'mud-wasps.' All they have to do, when a nest has been found, is to lay an egg upon the larva inside, penetrating the wall with the ovipositor. I am not certain whether these Fossors sting the prey so as to paralyse it; they possess very sharp and painful stings—as one soon finds out by picking them up in one's fingers.

The *Mutillidæ* are rather peculiar in that the females have no wings and are easily mistaken for ants. Their colouring, however, distinguishes them; they are black and red, or black only, with conspicuous large white spots. They particularly frequent rather dry open country, and may be seen running quickly over hot sand. Fossors, then, have evolved a unique method of ensuring a supply of fresh juicy meat to their young. But another of the great divisions of the *Hymenoptera* have altogether dispensed with a sting: these are the 'ichneumon flies,' called accursed by the mere collector of butterflies and moths, who is only interested in breeding a perfect specimen for show purposes, having obtained an egg, caterpillar, or chrysalis. Instead of the expected beauty, however, he only breeds a host of little beasts! These have come from eggs deposited by the parent ichneumon on the immature stage of the host. The ichneumon larva at first feeds only on the unessential fats and juices; so that if the prey is a caterpillar, it continues to feed and grow, and often even has strength to become a chrysalis, after which the

[1] Some species, however, have been found to prey upon *Glossina morsitans* in its pupal stage.

growing ichneumon larva consumes the whole of the interior of its host, and itself becomes adult.

The ichneumons are commonly called parasites, but it is a question whether the use of this term for a creature which necessarily destroys its host is not straining it to a degree quite unlawful. Only there seems no other word.

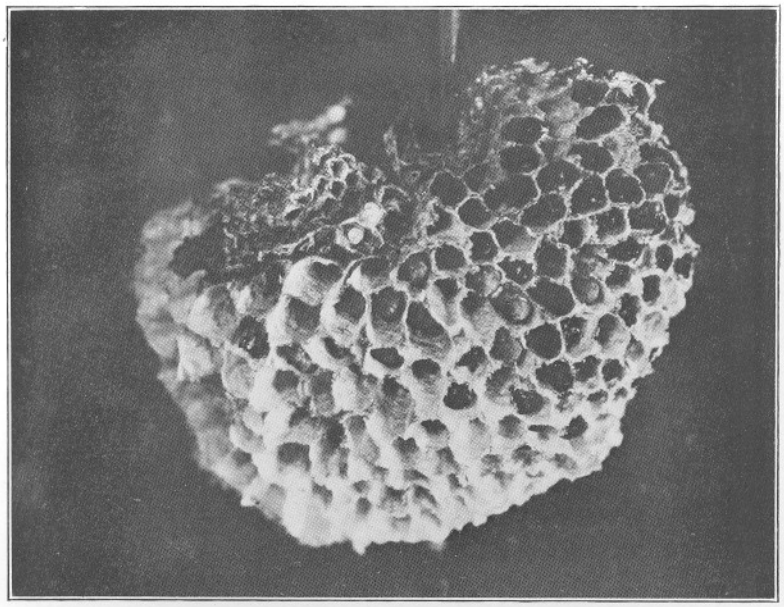
I noted a large ichneumon ovipositing upon a caterpillar, and it was interesting to see that it firmly grasped the body of the caterpillar with its mandibles, standing astride over the length of its body while piercing it with the ovipositor, the unfortunate caterpillar jerking itself from side to side in the vain effort to shake off its foe. The ichneumon adopted precisely the same attitude as that of a Sphegid when stinging a caterpillar, which gave one cause for thought.

The operations of the Fossors have long attracted much attention, owing to their complexity and uniqueness in the Animal Kingdom, and were long believed to illustrate the use of true intelligence and foresight.

But now, thanks to the observations of such as the gifted French naturalist Henri Fabre, and Mr. and Mrs. Peckham in America, we know that there is no intelligence at all concerned in the matter. From beginning to end the whole complicated series of operations is simply a chain of events, each one of which, when finished, provides the necessary stimulus for the next which follows—nay, *must* follow, the insect being unable to help itself! Thus, Fabre showed that if a Fossor be interrupted after she has dragged down the prey and deposited her egg on it, and the prey be withdrawn, on her return the insect will resume her work at the point she left off, and will fill up the burrow and smooth over the surface as if nothing had happened, when there was nothing in the burrow at all. Or, again, if the roof of a burrow of *Bembex*—which, as has been said, brings fresh supplies daily, be dug away, leaving the helpless grub exposed to view among débris of legs and wings of flies—what does the mother do when she returns? Does she excavate a fresh burrow, carry down her offspring, and feed them? Not a bit of it! As Fabre remarked, 'For her they cease to exist.' Since the stimulus supplied by alighting at the mouth of the closed

PHOTO NO. 3.

Wasp larvæ—

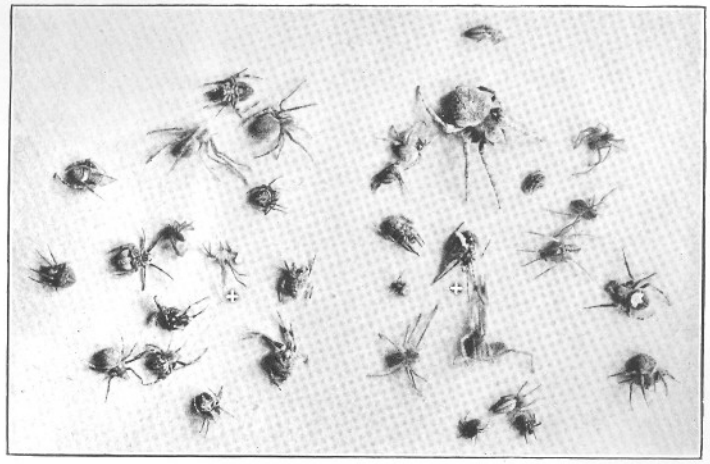


—Parasitic pu
from which fli
have emerged.

—Living pupa

"PAPER" NEST OF BELONOGASTER GRISEUS, Fabr.
Showing larvæ in unfinished cells; also pupæ of parasitic muscid, some hatched and others intact.
Photographed by Dr. G. van Someren.

PHOTO NO. 4.



CONTENTS OF TWO CELLS, FROM NEST OF SCELIPHRON SPIRIFEX, Linn.
The spiders are alive, but rendered helpless by poison from sting.
The spiders marked + have the wasp's egg attached.
Photographed by Dr. G. van Someren.

[*To face p.* 444

burrow, and having to reopen it, and pass down a tunnel, is wanting, she is unable to feed the larva. Indeed, she is unaware of its existence, although she may actually walk over it in her frantic searching for the mouth of the burrow which does not exist, while the precious larva she is impelled to feed slowly perishes in the sun.

Again, I have seen the following in the case of a Sphegid which stores up a single large caterpillar. If the paralysed prey be removed from the burrow and laid on the ground, the Fossor, on her return, will pounce on it and sting it again, precisely as if it were a fresh one, although, from the intelligence supposed to be employed, she should recognise it, especially as she had laboriously carried it a long way!

Moreover, the stinging of the prey, always supposed to be a marvellous instance of intelligent skill directed towards a selective paralysis of the main nervous centres, has been shown by the Peckhams to be very far from perfection. They found by examining a large number of cases among different species, and even individuals of the same species, every degree of difference between a prey that was so seriously stung that it succumbed, and, drying up, would not afford the juicy food that the larva requires, and the other extreme where the prey was so lightly injured that it very soon recovered all its powers of movement.

In the south of Europe, I remember finding the first Fossors at work that I had ever seen, and was much delighted. One was a species of Sphegid (*Ammophila*) which stored up a single large caterpillar. On one occasion, I had waited until the wasp had flown away after completing the series of operations, and then dug up the caterpillar with the egg affixed to its side. When put in a box the caterpillar was able to rid itself of the egg, and walked about and ate its food, though later it died.

Similarly, every degree of perfection may be found in the operations of bestowing the prey in the burrow. It may be said here that the usual method is to prepare a burrow and then fly off and hunt for the prey, which has then to be brought back. Very often, as when it is a large Noctuid caterpillar,[1]

[1] I have never noted a hairy or spiny caterpillar of a moth to be attacked by Fossors: the species seem always to be *Noctuidæ* or *Geometridæ*.

spider, grasshopper, or cricket, it is much too heavy to be carried in flight, and the Fossor then walks with it in her mandibles, carrying it up hill and down dale, over rocks with perpendicular faces, through all kinds of difficulties until, somehow or other, the toiler arrives back at the burrow. Sometimes the prey is too heavy even to be carried by walking, and requires to be dragged along: a tedious performance, so that the shorter the distance the better. In these cases the general rule seems to be that the Fossor first finds the prey, and then digs a burrow for it in the nearest suitable locality.

On one occasion, I was watching a Sphegid (*Ammophila beninensis*), which I found at the stage when she had arrived with her prey—a large Noctuid caterpillar—at the mouth of the burrow. The next step is always the same: the caterpillar, which lies helpless in a slightly curved attitude, is put down at the brink of the hole, with the head at the very edge. The Sphegid then goes down backwards, and at the last moment seizes the caterpillar with her mandibles, just behind its head, and drags it down to the chamber at the bottom of the burrow where there is room for both. There the caterpillar is bestowed, the Sphegid lays her elongated white egg upon its side at about the middle of the body, and, having climbed out, proceeds to fill up the burrow.

In this particular case, however, the caterpillar was so much too large for the chamber that the *Ammophila* could only just squeeze her way up the passage into which its tail projected—almost up to the surface. This would not do at all, and the chamber had to be enlarged; in order to do this it was first necessary to extricate the caterpillar from the burrow—a difficult job. However, she managed it. Standing over the mouth of the burrow, the *Ammophila* reached down and grasped the tail end of the caterpillar with her mandibles as far forward as she could reach, pulled it up and held it between her forelegs while she shifted her mandibles farther forward, and thus by repeated manœuvres was able to draw out the over-sized caterpillar. Down she went and enlarged the chamber with 'tooth and nail,' bringing out several 'armfuls' of earth, and depositing them, with a little buzz as of protest, a few inches away from the hole. Then she went in again,

dragging the caterpillar after her. But still the chamber was much too small, and the whole process had to be gone through again; but not until six attempts had been made to fit the caterpillar in was the process completely satisfactory.

On one occasion it had not been so carefully disposed at the edge as usual, and when *Ammophila* backed down the burrow she grasped the tail end instead of the customary place just behind the head, and it moved slightly.

Ammophila at once perceived that something was wrong, hurried up from the burrow, examined the caterpillar carefully, and rearranged it in the correct attitude; so that, going down, she was able to catch hold of the neck, which custom seems to require.

Here was a very imperfect worker, whose unskilfulness contrasts markedly with the nicety of method of another of the same species watched at a later date.

She was seen carrying along a large Noctuid caterpillar, very many times heavier than herself: it was grasped by her mandibles a little distance behind the head, and the end of the slightly curved body projected a little between the second and third legs of one side of the *Ammophila*. This I have found to be the rule when a Sphegid carries a caterpillar. I followed her carefully, for some twenty yards altogether, marvelling how straight a course she kept through and round obstacles. When she came to a certain point, without any hesitation at all, she struck off at an angle to the right and preserved the fresh direction in a straight line for several yards until, at a little bare spot, she put down her burden, scratched away a little earth, lifted away a small piece of stone in her mandibles, and disclosed the mouth of the burrow. As usual, she went down head foremost to see that all was well in the chamber at the bottom, and then came up, seized the caterpillar which lay correctly at the mouth of the burrow, pulled it down after her, and then having safely bestowed it in the chamber and laid an egg on it, came out and filled up the burrow in the usual manner without any delay, and flew off. No hitch here! The whole operation was carried out in a most workmanlike way, and as differently as possible from the bungling of the last one described.

It may be argued that such differences in expertness themselves imply the presumption of intelligence, which might be expected to vary in different animals.

More especially in the case of the last observation, when the Sphegid found her way back in such a direct manner, does it seem justifiable to call in the use of memory. Now *memory* implies *intelligence*. But we are begging the whole question here; for there is no word, in the operations of instinct, to compare with memory, which is only for intelligence. 'Instinctive memory' would be an absurd phrase; yet we have no word in English for what it implies—namely, a process of instinct comparable to the process of intelligence called memory.

The Fossors are of interest in so many ways that, in a discursive paper such as this, one is hard put to it to keep within even broad limits. For instance, there is their relationship to man and his environment—*i.e.* their *bionomics* in connection with man. In the case of the *Bembecidæ*, their direct relation to the health of man and his domestic animals is obvious, for they prey almost exclusively[1] upon two-winged flies, and more particularly upon the blood-suckers which transmit diseases. That they prey upon *Tabanidæ* has long been known; that they also prey upon *Glossina*, the Tsetse flies, has only been made known in recent years, owing to the increased attention paid to these very important flies.

Consider the *Sphegidæ*, some of which, for each larva, store up a number of small caterpillars; so that during the working life a single mother might destroy several dozen harmful caterpillars. Many Sphegids store up such destructive insects as crickets, grasshoppers, cockroaches, &c. It must be remembered that each Fossor has a certain type of prey—often a certain species only—on which the young are fed, and this is sought out from its most secret hiding-places.

On the other hand, certain Sphegids, and all Pompilids—so far as I have seen—prey upon spiders, in which case their activities by destroying useful creatures are positively against man's interests. Then there is the more complicated point

[1] I have recently seen one pounce upon and carry off a Hesperid or 'skipper' butterfly, drinking at the edge of a puddle.

still—namely, the case of the *Mutillidæ*, which, as has been said, lay their eggs in the nests of other *Hymenoptera*, including Fossors ; and, lastly, several Fossors have become thieves, and, instead of hunting for themselves, dart down at a favourable moment and lay their eggs on the prey which a more honest relative is about to store up for her own. The pirate larva develops more quickly, and hence the food is eaten before the rightful owner is full grown; hence it dies of starvation. Thus the pirate may, by destroying the destroyer of a harmful insect, range itself against man. And so the balance of nature swings, up and down, and man can only look on and marvel at the intricacy of it.

Having now broached the subject of the natural enemies of Fossors, I propose to make a diversion and discuss that point and its relation to the colours of these insects. The absorbing study of the colouration of insects has only been made intelligible by the Darwin-Wallace hypothesis of Natural Selection.

On this hypothesis, certain insects are rendered relatively inedible to mammals and birds by the possession of a disagreeable taste, a sting, extreme hardness, spines or hairs, &c. I may say, in passing, that this has now been abundantly proved by experiment with insectivorous animals and birds. It has been to the advantage of such insects that these qualities should be made known as efficiently as possible; for a mere experimental peck or bite or taste by an inquisitive enemy may destroy an insect as much as eating it, or at least render it incapable of reproducing its kind.

Hence natural selection has brought it about that such 'protected' insects have conspicuous, easily recognised, gaudy colours in simple patterns—such as the alternating rings of yellow and black exhibited by many stinging *Hymenoptera*, or the bright red and black of many *Acræa* butterflies. An insectivorous bird or animal, having in its youth learnt the disagreeable taste of such brightly coloured insects, for the future disregards them in favour of more edible food, so long as this is to be had, knowing that a conspicuously coloured insect is likely to be offensive. Hence such colours are known as 'aposematic'—a term which literally means 'warning off.'

The bearers of aposematic colouring may always be known by their bold demeanour: such an insect, instead of taking to flight, flaunts itself before you; or, if unable to fly, will not get out of the way, but displays to the utmost the characteristic signal of inedibility or the possession of an efficient means of defence.

Now, one family of the Fossors—although all the Fossors possess stings—is particularly interesting from the point of view of aposemes—namely, the *Pompilidæ*. Their flashing blue-black bodies and wings, often associated with canary-yellow legs and antennæ, make them most conspicuous as they sail by, or run over the ground; their stings are very painful, and they advertise to the eye very plainly that they had better be left alone. To the eye, I said, but also to the *ear*; and this is why the *Pompilidæ* are particularly interesting, for they have evolved a method of appealing to more senses than one. Many of the larger species make such a loud rattling noise as they fly that one's attention is irresistibly attracted—for they are often heard before they are seen—the noise being like the rattling of a particularly badly-made clockwork toy. It is obvious that to an edible insect such a noisy flight could be only the means of hastening its end: on the other hand, an enemy whose attention has been thus called to a particularly conspicuous insect leaves it severely alone. I have actually seen this with pet monkeys, tied up by a long cord: they have heard an approaching Pompilid, and watch it with suspicious care, and are very anxious not to interfere with it. I may say, in passing, that, for all their noise and unpleasant appearance, no Pompilid will interfere with you unless you interfere with it; and you can securely watch a most ferocious-looking species that would give you cause to regret it if you seized hold of it.

I know of no insects, save the *Pompilidæ*, that make what may be termed an *aposematic sound*. Many beetles, and ants such as *Megaponera fœtens*, and some *Hemiptera*, will make a stridulating noise when handled; but this is more of the nature of an intimidating sound, and not an advertisement made continually while the insect goes about its ordinary affairs.

It is rather interesting that the exact contrary may also

be observed among the Fossors: the family *Scoliidæ* having an extraordinarily noiseless flight, often not the slightest hum being audible from a much more bulky species than the noisy *Pompilidæ*.

It is common knowledge that every living thing produces during its lifetime vastly more offspring than can possibly survive: the world since long ages being fully stocked, though of course, here and there, a slight change of conditions locally may enable one species to increase, at the expense of another. Hence great numbers must be destroyed by enemies, disease, lack of food, or of space.

The degree to which this is the case is not realised without mathematical consideration. Commenting upon this struggle for existence, Wallace[1] takes the example of a pair of birds, producing four young at a time, for four seasons.

In fifteen years the progeny, allowed to multiply unchecked, would have reached the appalling number of more than *two thousand millions*! Wallace goes on to show that, at a minimal estimate, whatever the average number of individuals existing in any country, at least twice that number must perish annually. In the case of insects, the conditions may be represented clearly by an equation.[2] Let the total number of each generation be represented by X. Then since all but two will perish, the total number destroyed by all causes equals X — 2. Let V = number destroyed by vertebrate enemies, P the number destroyed by predaceous insects, and p by parasitic insects, and m by micro-organisms of disease. Then—

$$X - 2 = V + P + p + m.$$

The number destroyed by vertebrate enemies would be—

$$V = (X - 2) - (P + p + m).$$

That is to say, if, as I have claimed for *Pompilidæ*, the number destroyed by birds and animals is practically *nil*, then other (invertebrate) enemies must do the work, otherwise Pompilids would overrun the world and die of starvation.

[1] *Natural Selection and Tropical Nature*, 1895, p. 24.

[2] This equation was first stated at the meeting of the British Association in 1913.

What, then, are the enemies that keep down the numbers of *Pompilidæ* and other Fossors? The answer is: Other insects, either as before mentioned—such as *Mutillidæ*, which are directly 'parasitic,' or sundry other 'indirect parasites,' some Fossors, some two-winged flies—which appropriate to their own use the prey stored up by the Fossor.

Indeed, it seems, in some cases, that the Fossor is aware of the danger. The long journey which the helpless prey has to make to the burrow, during which it is often put down while the bearer rests, or is perhaps frightened away, provides ample opportunity for an alert pirate to dart down and lay her own egg upon the prey. An especially favourable opportunity is provided when, having arrived at the journey's end, the rightful owner of the prey puts it down at the mouth of the burrow and goes down to see that all is well below.

I saw a very astonishing thing once. An *Ammophila* had just come up from laying her egg on the caterpillar bestowed underground when I frightened her away, got out the caterpillar and laid it on the ground. When the Sphegid returned, she very carefully examined the caterpillar, discovered upon it the egg which she had herself deposited, and, to my great amazement, sucked it dry and deposited another! There are many very puzzling points about this, however one tries to explain it: one can only suppose that the custom is thus to destroy any egg found affixed. For many caterpillars are attacked by Tachinid flies, which deposit eggs upon their skin, and such would be useless as food for a Fossor larva as well as that of the fly.

A very common small *Sphex*, that feeds her young on grasshoppers, is intensely suspicious of the approach of any other insect while she is engaged with her task, and charges fiercely with open mandibles at even the smallest ant which draws near by accident—much to the alarm and confusion of the ant, be it said. (*Vide* Frontispiece, Fig. 7, *Sphex luteipennis*, Mocs.)

In the case of *Bembecidæ*, it is almost the exception not to find in attendance near the mouth of the burrow a quiet little brown fly—an undescribed species of *Idia*—waiting its chance. The moment *Bembex* leaves her burrow, *Idia* hurries

there; often literally tumbling head over heels in its hurry to do its duty to the race before the return of the formidable creature whose young it is going to supplant with its own. Should the burrow be left open—for *Bembex* sometimes is careless—*Idia's* chance has come, and in the fly scrambles, very quickly hurrying out again when the eggs have been laid. More often *Bembex* has temporarily closed her burrow, and in her absence the fly feverishly seeks an entrance—obviously working against time, for often *Bembex* will return suddenly, and the fly has to withdraw. It must be said, however, that I have never seen the *Bembex* take any notice of this insignificant little intruder. Nevertheless, one often finds that *Idia* has been captured and paid the penalty—itself to be stung and stored up as food for the *Bembex* larvæ. On the other hand, small larvæ of a two-winged fly—presumably *Idia*—are often found, several at a time, in the burrow of *Bembex*; but it is possible that they are really only scavengers, devouring the débris left by the *Bembex* larvæ, and do not attack the lawful owner of the nest.

Fossors at work are quite the most active insects I know. The nests of ants or bees do not compare in feverish activity with such a scene as may be witnessed on an open sandy space where numbers of *Bembex* are working together, as I have often found on the shore of Lake Victoria. On first arrival, you will perhaps see nothing very much but a number of pale yellow and black, waspish-looking insects, sitting on the sand or restlessly flying about with a remarkably dashing flight, so that the eye cannot follow them. These are males—idle fellows who have nothing to do but find their mate; hence, probably, the way in which they dash about to make the acquaintance of a member of the opposite sex. Suppose—as is often the case—there are numerous Tsetse buzzing around you or settled on your puttees: you will see a very interesting thing. A female *Bembex* comes and apparently investigates you very closely, flying round and round at about the level of your knees. But there is no cause for alarm: it is not you, but a full-fed Tsetse, bloated with a heavy meal of your blood, that she wants. Failing this, she will select the next fattest she can find, which will be a gravid female, with abdomen swollen by

the large larva inside. Presently, you hear her pounce on such a one with a quick rush; there is a short, high-pitched buzz, like a squeal, from the unfortunate fly as it is stung; and if you are quick with your eyes, you will see the *Bembex* dart away, holding the paralysed fly between the thighs of her middle pair of legs. She alights at a spot where the bare sand shows to you no difference from the surrounding area; but *she* knows it, for did she not take great pains to cover up the mouth of the burrow that is there before she went away, to obstruct the thieving *Idia*, which you may see hanging round, a little distance off? She alights on the sand, holding her prey between her thighs, and without a moment's pause she begins to dig with her powerful fore-limbs, furnished with strong bristles. But dig is a feeble word for the energy displayed. The sand is hurled backwards by the rapid movements of her fore-limbs, working so fast that a continuous shower of sand passes under her body to fall several inches away.

As she digs, the loose sand keeps falling in; but she perseveres until the opening is clear. Occasionally such a quantity has to be dug out that it accumulates in a little heap behind her and begins to trickle down again. So she begins at the far side of the pile and works her way forward, right through it, until the mouth of the burrow is clear, when down she goes, never having let go for one moment of her precious fly. The waiting *Idia* seizes this opportunity to approach nearer, and waits at the very brink of the hole for the critical moment. Out comes the *Bembex*; and if she is a careful worker, turns round and throws enough sand backwards to cover the mouth of the burrow before going off to seek fresh food for the hungry larva inside. This is *Idia's* chance; and with laughable eagerness it attempts to penetrate into the burrow, scrambling in such haste that often it literally tumbles head over heels. No matter, there is need for haste; for who can tell at what moment *Bembex* may return again? So the little fly searches feverishly for some crevice which the *Bembex* may have left uncovered, that it may penetrate down the deep burrow and lay its eggs there. Often the *Bembex* has carefully rendered this impossible, and her sudden return necessitates hurried

retreat—the fly ' knowing ' the sound of her wings, and retiring before she actually alights. Sometimes, however, the careless *Bembex* has failed to seal the entrance, and *Idia* has its chance, and the *Bembex* larva is perhaps supplanted in its birthright.

The *Bembecidæ*, as has been said, usually feed their larvæ on flies, very often selecting especially the blood-suckers.[1] I have found in the nest of *Bembex capensis* remains of *Tabanus thoracinus* and *Chrysops brucei*, and seen it carry into its burrow a full-fed *Glossina*. I have watched *Bembex forcipata* carry down one Tsetse after another, so that in three and a quarter hours twenty-nine Tsetse and two other flies had been taken into the burrow, which, when opened, was found to contain thirty-one Tsetse. Another burrow was opened up and the larva removed and put into a pill-box, when it ate nine Tsetse flies in twenty-one hours. This was more than half grown: it would seem that if it only requires a week to become full fed, it must devour some forty or fifty flies. When full fed it spins a neat pear-shaped cocoon of silk, grains of sand being firmly embedded in the outer covering, in which it changes into the quiescent pupa, from which the perfect insect emerges in a few months.

It may have been noticed in the accounts given that *Bembex* never puts her prey down, but holds it always pressed close to her body, so that her enemies have not the chances given to the enemies of two other families—*Pompilidæ* and the burrowing members of *Sphegidæ*. *Sphegidæ* differ considerably from *Bembecidæ* in appearance: instead of rather a broad black-and-yellow abdomen, they have a long narrow abdomen, with often an extremely elongated, slender pedicle, and their colouring is mainly black, with an admixture of a little dull red, white, or yellow (*vide* Frontispiece, Fig. 7, *Sphex luteipennis*). They are of varied habits, but all agree in supplying their young with paralysed prey, of which an ample supply is provided once, for good and all; the young being left entirely to itself.

I noticed one species, whose name I forget, making use of a dead hollow cane as a nursery, so that it saved itself all the trouble of either burrowing or building; this habit, how-

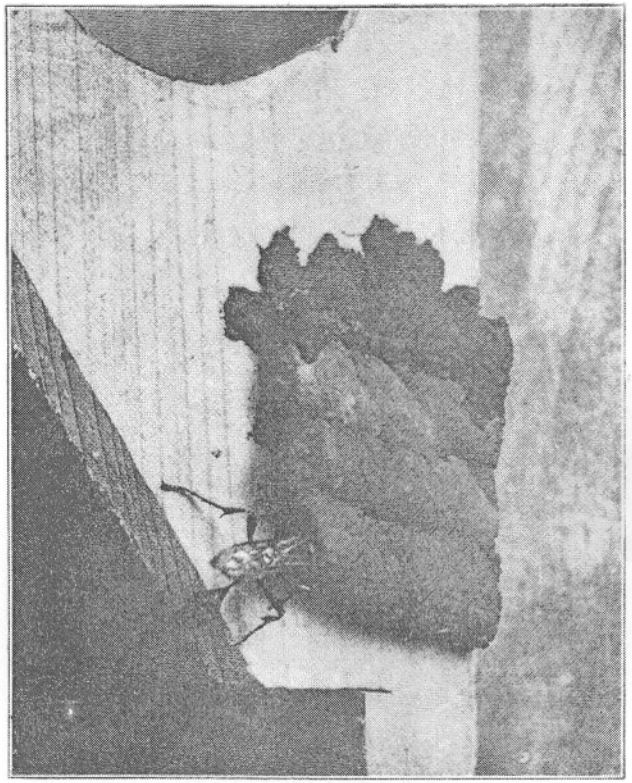
[1] *Sleeping Sickness Commission of the Royal Society*, Report No. XII, 1912.

ever, is exceptional among Fossors. It is matched among bees, many genera of which make their nests in convenient empty receptacles such as snail-shells, hollow stems, &c.

Let us spend a few minutes over *Sceliphron spirifex* (*vide* Frontispiece, Fig. 3, *Sceliphron spirifex*, L., and photo 5)—a very familiar species in houses—the long-legged, black and canary-yellow 'mud-wasp,' so detested by housewives because of the mud nests it makes behind pictures, inside the backs of books, &c., wherever it finds a secluded nook that suits its fancy. Its habits are much like those of the *true* 'mud-wasps'—black insects with red, or orange-tipped, abdomen (*vide* Frontispiece, Fig. 4, *Synagris negusi*) that have the folded wings of the true wasps, but lead solitary lives. These, however, always make a single large nest, composed of many cells under a common outer shell, stuffed with caterpillars, the united mass being as big as one's fist. *Sceliphron* builds a number of separate cells, each about an inch long, of internal calibre the diameter of a lead pencil. Often she puts one against the other, but not by any means of necessity. The home of each larva is complete in itself, and a wonderful bit of work, too! The little *banda*, in which I now write, is noisy with these busy workers from 7 A.M. to nearly sunset. First the sonorous hum, which has caused the Baganda to call *Sceliphron* 'Bumbuzi'; then the curious high-pitched buzz, rising and falling as with deft manœuvres one spreads out the pellet of moist earth which she has brought, making it adhesive with saliva, so that it binds to the last layer. The cell is begun at one end and built in sections, each pellet that is brought making a new section, the bore being kept very uniform. Immediately one pellet has been used, off she goes, to return with another in a very few minutes. The pellet is about the size of a sweet-pea seed, and is held in her mandibles.

While writing one morning, I timed the journeys of a single worker which was commencing a nest where I could watch its arrivals and departures. The following times represent her arrivals with a fresh pellet: 8.45, 8.48, 8.50½, 8.57½, 9.1, 9.6, 9.8½, 9.12½, 9.17, 9.23½, 9.27, 9.30, 9.33½, 9.36½, 9.39½, 9.41½, 9.44½, 9.47.

Photo No. 5.

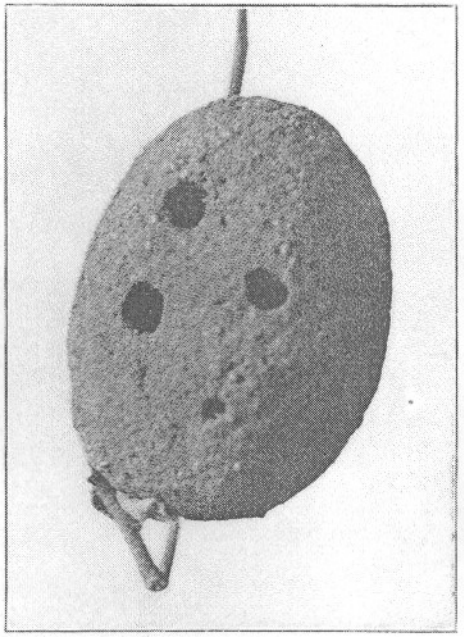


SCELIPHRON SPIRIFEX, Linn.

Showing three completed mud cells which have been filled and sealed, and fourth tube nearing completion.

Photographed by Dr. G. van Someren.

Photo No. 6.



"PLUM" NEST OF WASP ALLIED TO SYNAGRIS.

Photographed by Dr. G. van Someren.

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Apparently the cell was then finished, for she did not return for half an hour, when I went out. She had made eighteen journeys, and the time taken by each complete cycle of arriving with a pellet at the nest, building up the material, flying away, collecting another pellet and arriving with it, *averaged only* 3·6 *minutes*, varying from two to seven. There are, I think, few bees that could compare with that. The completed cell is stuffed with spiders; but the amount of food provided varies very greatly—some larvæ have a superabundance, while others scarcely seem to have sufficient. I have counted the number in twenty-nine cells—it varied from one to nineteen. The single one was only a very little larger than others of which several may be found in one cell. The average number was 9·3. In one case five cells were aggregated together, and that single *Sceliphron* had accounted for *sixty-eight spiders*—even if, which is unlikely, those were the only cells she would make, or had made, during her life.

The spiders are of many species—often each one in the cell may be a distinct species. They are usually of the web-spinning type, with rotund, fat bodies.

Sceliphron has her enemies, and, curiously enough, the most conspicuous is a large ichneumon of the same black and canary-yellow colouration, and quite easily mistaken for *Sceliphron*, though its legs are longer. This is almost certainly a case of Mullerian, or synaposematic, resemblance—one form of mimicry. One would like to say a little more on this subject, but this paper is quite long enough. It may just be mentioned, however, that synaposematic resemblance is beautifully exemplified among Fossors by both *Sphegidæ* and *Pompilidæ*, which resemble in colouring the well-known and conspicuous black-and-orange Lycid beetles which have been proved to be highly distasteful to insect-eating animals. Before leaving *Sceliphron*, I should like again to allude to its extremely curious song while working. It must be produced by rapid vibration of some parts of the wing, but it is extremely difficult to ascertain. Certain flies—Hover-flies or *Syrphidæ*—which one often finds on window-panes, produce a high-pitched, gradually rising, note by very rapid, but limited, vibrations of their wings while they are apparently closed

over the back, and the noise made by *Sceliphron* may be analogous.

This singing at work seems to be the prerogative of the *Sphegidæ*. I cannot, for the moment, remember that the *Pompilidæ* ever do it, and *Bembex* certainly does not. Often, if you observe with your ears, as a field naturalist should do, and not only with your eyes, your attention will be attracted by an intermittent buzzing which, as you trace it to its source, seems to come from under the ground. Approach gradually, and you will see a small round hole with freshly excavated earth at its mouth. Suddenly, a long, thin-bodied insect backs out of the hole, bearing between her fore-limbs an 'armful' of earth, which she puts down a few inches away—often with a little buzz, as if of satisfaction. She again launches herself into the hole with headlong vigour, and a loud buzzing attests her efforts to loosen the firm soil.

If you have watched one from the commencement of digging the burrow, you will see that she endeavours to scrape out an 'armful' of earth with her powerful fore-limbs; but if it is too hard, or she meets with a small pebble in the way, she has to bite it out, and this always produces a sort of protesting buzz at being so hampered in the work; for these Fossors seem to work at very high pressure, and as if on springs, antennæ vibrating and wings flicking with superabundant energy. Finally, the chamber at the bottom of the burrow, several inches underground, is completed, and all is ready for the prey. If the accustomed prey is of large size it has been first found and stung, and the burrow excavated close to where it lay. If the Fossor is one that chooses prey which she can carry, the burrow is first made, the prey then sought out and brought back.

Having satisfied herself that the home is ready, the Sphegid pays particular attention to concealing the entrance before she goes away. A few small bits of stone are picked up in her mandibles and securely wedged in the entrance, and she then stands with her head away from the spot and scratches fine earth backwards so as to conceal completely the mouth of the burrow. Finally, after very careful examination, she flies off, and then you may see her quartering the ground for the

prey she is in need of, be it caterpillar or a grasshopper, cricket, or other member of the *Orthoptera*. She hurries about, antennæ vibrating, wings flicking, examining every likely locality, until suddenly—Pounce! She has found it; there is a brief rough and tumble, and in a moment the prey has been stung, and the successful huntress starts to carry it back. This journey has, in one case, already been described. On arrival at the burrow, the Sphegid puts down her prey, discloses the mouth of the tunnel, and goes down to see that all is well, as has been described. This is the opportunity for which her enemies are waiting to hurry down and lay their own eggs on the prey which they do not get themselves.

The prey having been safely bestowed, and an egg laid upon it, the Sphegid proceeds to close the burrow. Standing with her head away from it, she scratches loose earth backwards, with sure aim, so that it falls into the hole. But a mere accumulation of loose earth is not enough—it would soon sink and leave a hollow, revealing the existence of the burrow: it must be pressed down.

This is an extremely interesting part of the performance, for reasons that will be seen later when the work of the *Pompilidæ* is described. The Sphegid uses the front of her broad head as a battering-ram, and, getting a firm hold of the sides of the burrow with her last two pairs of limbs, launches herself down the burrow, pressing down the loose earth to the accompaniment of a buzzing sound. Occasionally a small bit of stone is picked up in her mandibles, put down the burrow, and rammed home in the same way; finally, loose earth is scratched over the surface, and, having thoroughly satisfied herself that the surface of the ground gives no indication of the treasure beneath, the Sphegid flies off to refresh herself on a neighbouring flower before repeating the whole laborious process.

Lastly, mention must be made of the large family *Pompilidæ*, whose habits in all essentials are similar to those just described. These Fossors have not the very long, narrow pedicle to the abdomen so often seen in *Sphegidæ* and true wasps such as *Belonogaster*, and their legs are longer in proportion; their clockwork flight and aposematic colouration have already been mentioned. So far as I know, they confine

their attentions entirely to spiders—even the very largest 'tarantulas' that burrow in the ground are not immune.

The process of excavating a burrow is essentially the same as in the *Sphegidæ*, and carried out with the same extraordinary vigour. But, speaking from memory, I have found the *Pompilidæ* to work *silently*.

When the time comes for filling up the burrow and ramming down the earth, however, the *Pompilidæ* show an extraordinary difference from the *Sphegidæ* in their methods. As was said, a Sphegid uses the front of her head, with steady pressure, to ram in the earth; but a Pompilid does exactly the opposite. Standing over the mouth of the burrow, she puts down her tail and uses it to press down the earth—sometimes with slow, steady movements. In one case that I observed, however, a series of quick blows was struck, the Pompilid throwing her whole body into such rapid vibrations that her outline was blurred, and she reminded one of the operations of a pneumatic riveting-hammer. This difference between the two closely allied families I have found so invariable that if I were asked whether a given specimen were Sphegid or Pompilid, I should say: 'Let me see it filling up its burrow, and I will tell you!'

A unique and remarkable observation that fell to my lot seems to indicate that not all *Pompilidæ* make burrows. I saw, in Tero Forest, a medium-sized typical blue-black specimen pounce on a spider, lay an egg upon it, and depart. The spider did not seem to have been stung at all, and it would seem as if this aberrant Fossor had lost its instincts of burrowing, and merely laid its egg on the surface of its living prey, as do the parasitic Tachinid two-winged flies.

With these notes I will conclude these discursive remarks; but enough has been said to show how many subjects are embraced by the study of these fascinating insects—to my mind, far more attractive than their much-belauded relatives, ants and bees.

The questions of Instinct or Intelligence, of Natural Selection and the Struggle for Existence—the colours of insects made intelligible by the former, and their destruction by enemies exemplifying the latter—have all been touched upon.

I hope these notes will lead others to watch them. They are the most easily studied of any *Hymenoptera*. So long as one sits quietly beside the burrow, they will carry on; though an incautious movement will frighten them away, they always return, and never, under any circumstances, need the most timorous observer fear them, for their sting is reserved for the prey alone.

The observations herein upon *Bembex* were published in the 'Reports of the Sleeping Sickness Commission of the Royal Society'; those upon *Sphegidæ* and *Pompilidæ* have appeared in sundry publications of the Entomological Society of London.

DISEASES OF STOCK IN LUMBWA DISTRICT

By C. M. Dobbs

1. {*Rinderpest*, and *Gastro-enteritis*.} Lumbwa, *Kakatanet* or *Kipkaita*.—I have bracketed both these diseases together, as, until a few days ago, I have been unable to discover that the Lumbwa differentiate in any way between the two. The disease is endemic in this district, carrying off both adult and young stock—mostly the latter. It appears to break out with particular violence towards the close of the dry weather, and disappears again in the epidemic form with the advent of the rains. The two names used—as far as I can discover, interchangeably—refer to different symptoms. *Kakatanet* is the Lumbwa for the gall-bladder, and this appears to swell up and become full of a blackish-coloured liquid. *Kipkaita* refers to the diarrhœa or dysentery from which the animal suffers. In the case of adult stock, death takes place on the fifth day from the time the animal gets sick. Dysentery appears on the third day. If the animal survives past the